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STUDENT WORKBOOK

PARALLEL CIRCUITS

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US ARMY ENGINEER SCHOOL - FORT BELVOIR, VIRGINIA

D103.120:

PARALLEL CIRCUITS

INTRODUCTION

As seen in the preceding lesson, problems involving the determination of resistance, voltage, current, and power in a series circuit are relatively simple. It is necessary only to draw the circuit, to list the known values, and to determine the unknown values by means of Ohm's Law, the power formula, and the laws for series circuits.

Problems involving the determination of resistance, voltage, current, and power in a parallel circuit are solved as simply as in a series circuit. The procedure is the same - (1) Draw a circuit diagram, (2) State the values given and the values to be found, (3) State the applicable equations, and (4) Solve for the unknown.

The purpose of this lesson is to provide you with an understanding of parallel connected voltages and resistances. After completing this lesson you will be able to:

1. Explain parallel connected voltages.
2. Explain parallel connected resistances.
3. Analyze parallel circuits to determine voltage, current, resistance, and power.

This publication supersedes Student Workbook, 52B20-B-010-050, September 1975, PARALLEL CIRCUITS.

1. PARALLEL CONNECTED VOLTAGES

As mentioned before, each electric circuit requires a voltage source. One source for a direct current circuit is a cell or battery. The arrangement of the cells in a circuit depends on the load requirements of voltage and current. If the current requirement is high, cells are connected in parallel.

a. Current Capacity

As stated in the previous lessons, the voltage of a primary cell is 1.5 volts. Cells are also rated by current. The current rating of cells is based on a cells capacity or ability to furnish a certain amount of current for a certain length of time. The unit in which this capacity is expressed is the ampere-hour. The lifetime of cells can be increased by connecting more cells in parallel.

b. Connecting Cells in Parallel

A of Figure 1 shows four 1.5-volt dry cells connected in parallel. Note that all the positive terminals are connected together. Likewise, all the negative terminals are connected together. B of Figure 1 is a schematic drawing of the four cells in parallel. When cells are connected in parallel, the total current obtained is equal to the sum of the currents drawn from the individual cells. Also, when cells are connected in parallel, the voltage applied to the circuit is the same as the voltage of one cell.

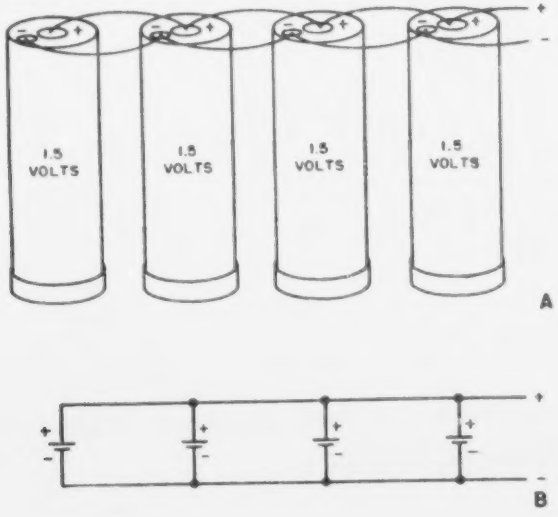
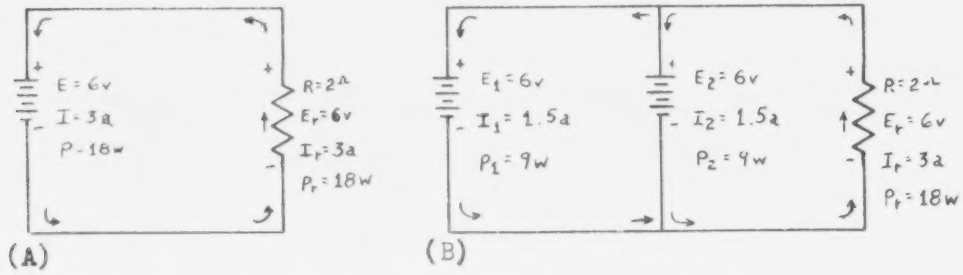


FIGURE 1 - PARALLEL VOLTAGE CONNECTION

c. Effect of Parallel Voltages

When batteries are connected in parallel in a circuit, there is no change in the electrical power supplied to the load. A of Figure 2 shows a 6-volt battery connected to 2-ohm resistance. According to Ohm's Law, the current flow is 3-amperes. The single battery is required to furnish the full power of 18 watts. When another battery is connected in parallel with the first (B of Figure 2), each battery is required to furnish only 1.5 amperes and half of the power to the load. If a third battery is connected in parallel (C of Figure 2), each 6-volt battery is only required to furnish 1-ampere of the total current of 3 amperes and 6 watts of the total power of 18 watts. Since there is less of a drain on each battery connected in parallel, it is understandable that they will last longer.



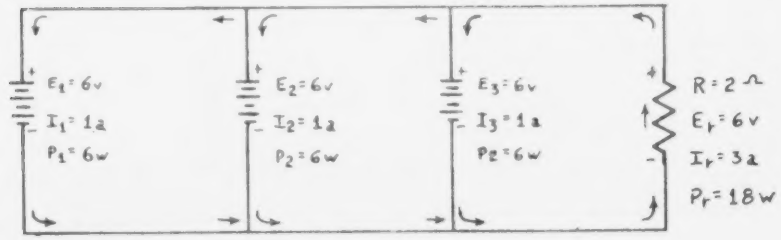


FIGURE 2 - EFFECT OF PARALLEL VOLTAGES

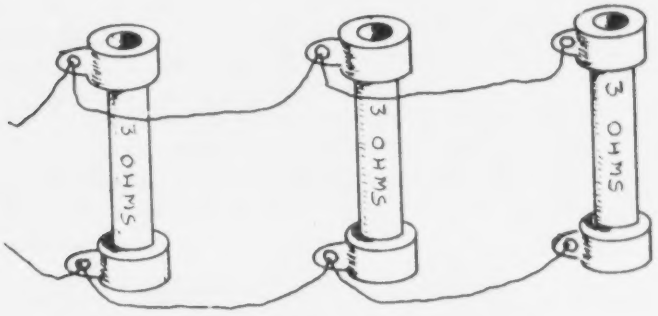
2. PARALLEL CONNECTED RESISTANCES

As mentioned before, each electric circuit will have some type of load. The load may be a resistor, a lamp, a heater, a motor or any other type of appliance. Each of these devices offers opposition to the flow of current.

a. Connecting Resistances in Parallel

A of Figure 3 shows three 3-ohm resistors connected in parallel. The conductor connects the resistors into separate branches. When resistors are connected in parallel, the total current divides and only part flows through each individual branch. B of Figure 3 is a schematic drawing of the three resistors in parallel. The resistor symbol may also be used in simple diagrams to represent any resistance rather than the symbol of the actual component.

(A)



(B)

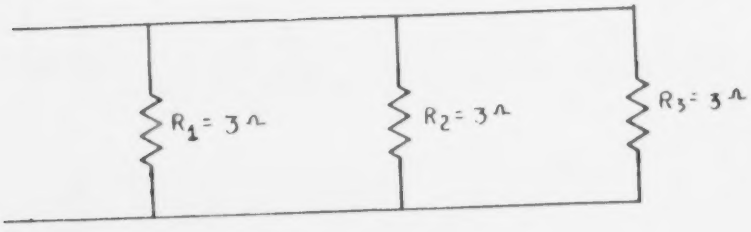
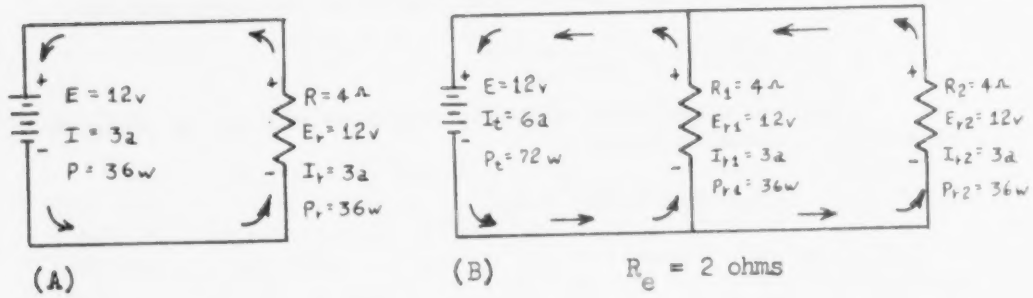


FIGURE 3 - PARALLEL RESISTANCE CONNECTIONS

b. Effect of Changing Resistance

According to Ohm's Law, the current in an electric circuit is inversely proportional to the resistance of the circuit. If the voltage is kept constant and the resistance is increased, the current will decrease. The opposite is also true, if the resistance is decreased, the current will increase. The circuits shown in Figure 4 are alike in that they have a 12-volt source connected to a resistance. The difference in the three circuits is in the number of resistances connected in parallel.



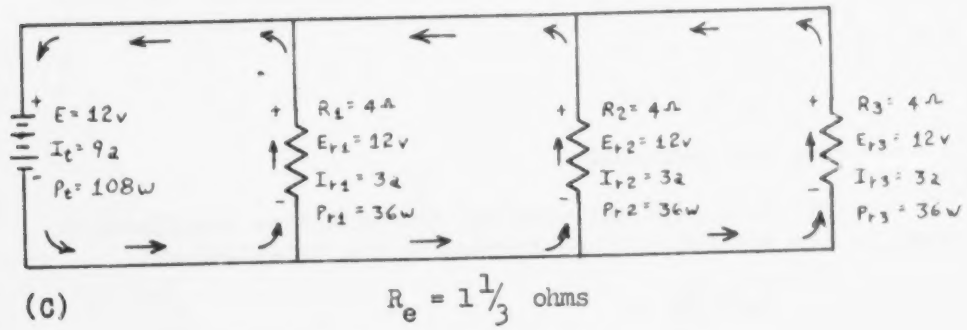


FIGURE 4 - EFFECT OF CHANGING RESISTANCE

3. ANALYSIS OF A PARALLEL CIRCUIT

If a circuit is designed so that there are separate branches for current to flow, the circuit is called a parallel circuit. By carefully tracing the connections of each battery, resistance and conductor, it can be determined that there are separate branches for current to flow (A of Figure 5). In analyzing a parallel circuit, Ohm's Law, the power formula, and laws for parallel circuits are used as required (B of Figure 5). The laws for parallel circuits should be learned.

a. Laws for Voltages

(1) In a parallel circuit, the voltages applied to the circuit is equal to any one of the individual voltage sources.

$$E_t = E_1 = E_2 = E_3$$

(2) In a parallel circuit, the same voltage is applied to each individual branch.

$$E_t = E_{r1} = E_{r2} = E_{r3}$$

b. Laws for Current

(1) In a parallel circuit, the total current is equal to the sum of the currents in the individual resistive branches.

$$I_t = I_{r1} + I_{r2} + I_{r3}$$

(2) In a parallel circuit, the total current is equal to the sum of the currents drawn from the individual voltage sources.

$$I_t = I_1 + I_2$$

c. Laws for Resistance

(1) In a parallel circuit, the effective resistance is equal to the applied voltage divided by the total current.

$$R_e = \frac{E_a}{I_t}$$

(2) In a parallel circuit, the effective resistance is equal to the reciprocal of the sum of the reciprocals of the individual resistances.

$$R_e = \frac{1}{1/R_1 + 1/R_2 + 1/R_3}$$

(3) In a parallel circuit, the effective resistance is always less than the lowest resistance in the circuit.

d. Laws for Power

(1) In a parallel circuit, the total power consumed is equal to the power consumed by the individual resistances.

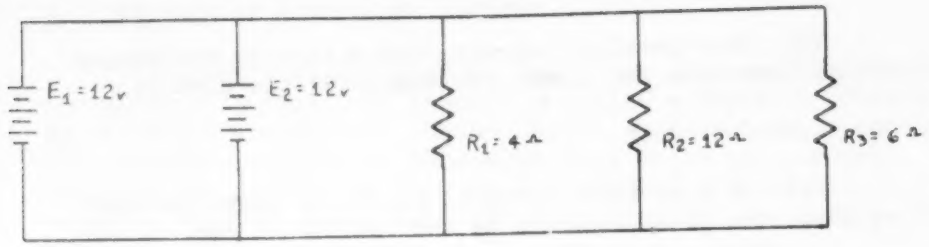
$$P_t = P_{r1} + P_{r2} + P_{r3}$$

(2) In a parallel circuit, the total power supplied is equal to the sum of the power supplied by the individual voltage sources.

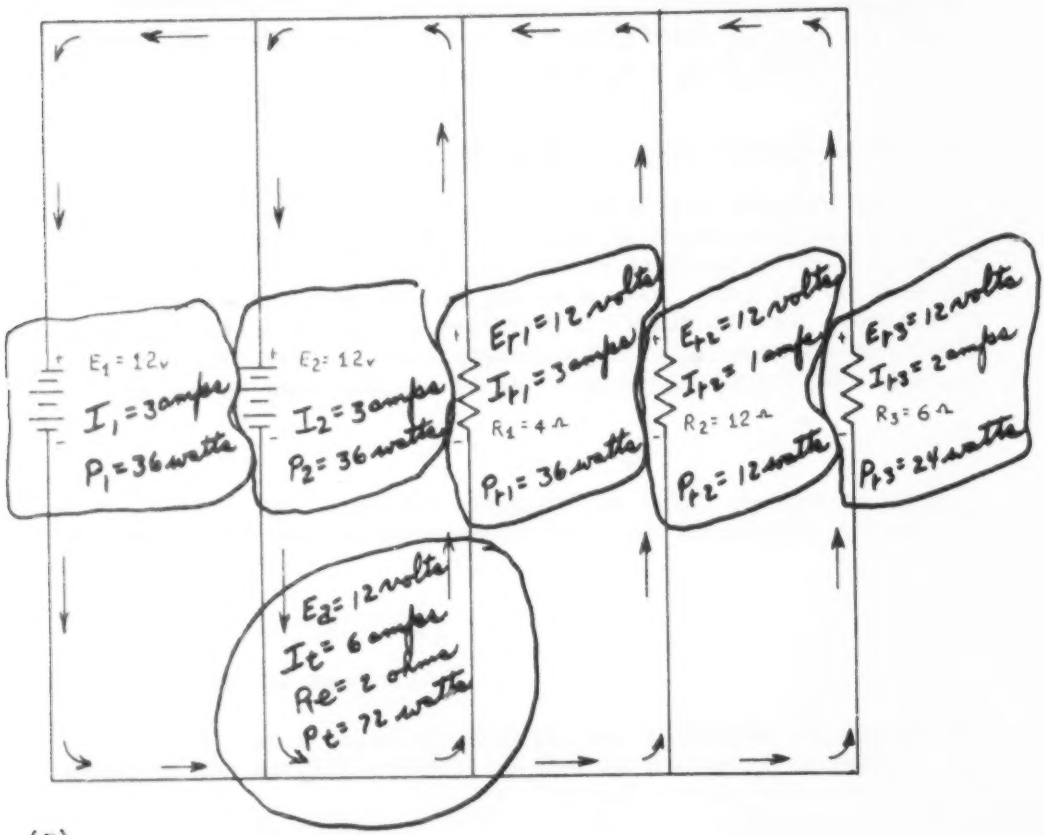
$$P_t = P_1 + P_2 + P_3$$

SUMMARY

Most circuits for electric power are connected in parallel. The circuits in a house or building are connected so that the loads will be in parallel with each other. With this type of connection, the same voltage is applied to each load. Each resistance, that is placed in parallel in the circuit, decreases the effective resistance of the circuit and allows more current to flow and, therefore, more power to be consumed.



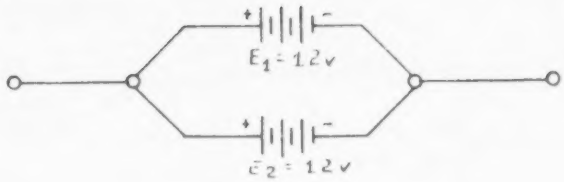
(A)



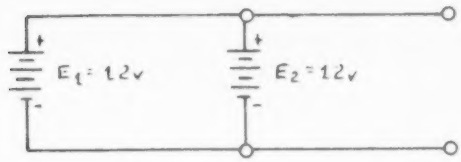
(B)

FIGURE 5 - ANALYSIS OF A PARALLEL CIRCUIT

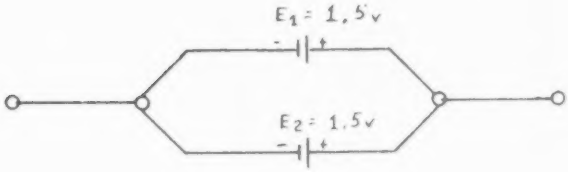
PROBLEMS:

1. 

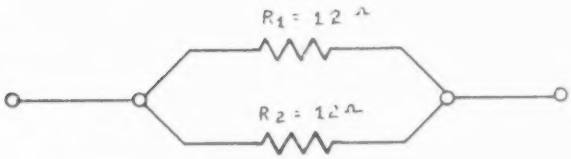
E_t = _____

2. 

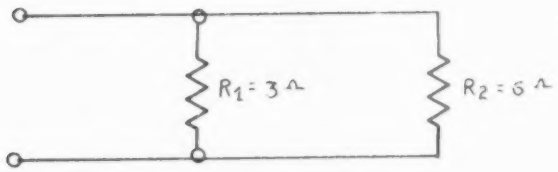
E_t = _____

3. 

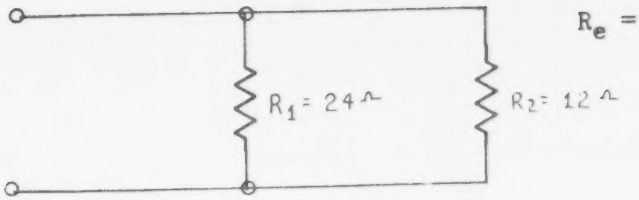
E_t = _____

4. 

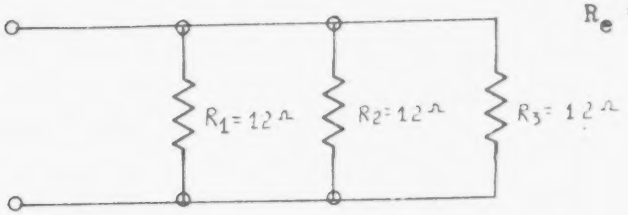
R_e = _____

5. 

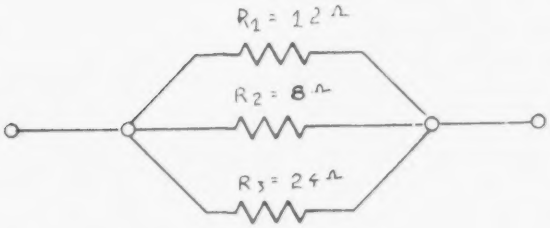
R_e = _____

6. 

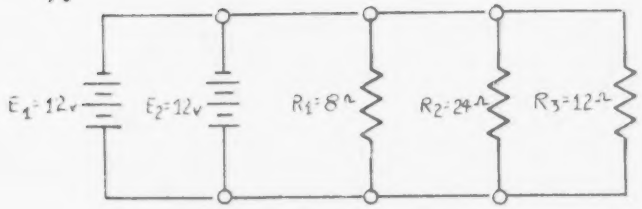
$R_e =$ _____

7. 

$R_e =$ _____

8. 

$R_e =$ _____

9. 

$E_t =$ _____

$I_t =$ _____

$R_e =$ _____

$P_t =$ _____

$E_{r1} =$ _____

$I_{r1} =$ _____

$P_{r1} =$ _____

$E_{r2} =$ _____

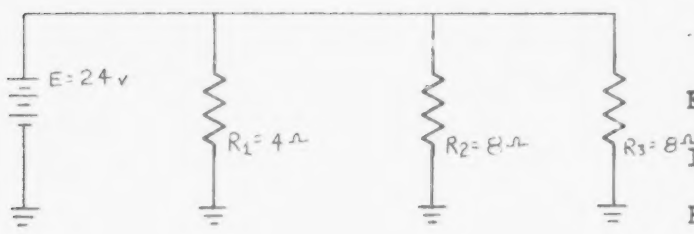
Continued

I_{r2} = _____ I_{r3} = _____

P_{r2} = _____ P_{r3} = _____

E_{r3} = _____

10.



R_e = _____

I_t = _____

P_t = _____

E_{r1} = _____

I_{r1} = _____

P_{r1} = _____

E_{r2} = _____

I_{r2} = _____

P_{r2} = _____

E_{r3} = _____

I_{r3} = _____

P_{r3} = _____

STUDENT NOTES:

INTRODUCTION

1. Parallel Voltages

2. Parallel Resistances

3. Parallel Circuit Analysis

SUMMARY

☆ U.S. Government Printing Office: 1986—491-036/52455